INTERPRETATION OF PROBLEM BASED LEARNING - A SYSTEMS DYNAMIC APPROACH

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ABSTRACT

This paper explores Problem Based Learning (PBL) by applying system dynamics methods that consider causal relationships among phases of PBL. The analysis explores three fundamental questions: 1) What is the relation between student effort and PBL success? 2) What is the best way for instructors to improve the effectiveness of PBL? And 3) what is the relationship between rates of knowledge accumulation and the development of effective learning strategies? We apply a computer simulation model to investigate complex and qualitative adaptations as student navigate through the phases of PBL. We identified the accumulation of knowledge as a key process that links student investigative activities to problem solution alternatives. The results suggest that performance driven students generate fewer solution alternatives than mastery driven students. The simulations revealed cyclical patterns of effort for performance driven students.

INTRODUCTION

This paper explores PBL by applying system dynamics methods that consider causal relationships among phases of PBL. The analysis explores three fundamental questions: 1) What is the relation between student effort and PBL success? 2) What is the best way for instructors to improve the effectiveness of PBL? And 3) what is the relationship between rates of knowledge accumulation and the development of effective learning strategies? We apply a dynamic simulation model to investigate complex and qualitative adaptations as student navigate through the phases of PBL.
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During PBL activities students exhibit a complex variety of learning strategies including choosing and refining solutions, using past knowledge to direct additional explorations, interacting with the learning environment and revisiting and revising past alternatives. These activities are interdependent and exhibit loops of causality as each activity influences and is influenced by other activities.

As students investigate a problem their mental models and decision strategies change as problems solving knowledge accumulates. PBL at its core is recognizes the importance of feedback where students' initial approach to a problem situation is continually refined as they generate new information and propose new alternatives. Students must continually challenge past solution approaches as they better understand the problem's context.

The complex dynamics of PBL and student motivation requires richer modeling approach to yield insight feedback processes. Dynamic systems modeling can augment correlation research models that identify sets of independent factors that act in a linear manner to explain levels of student effort. Additional insights can be gained from modeling reciprocal causality, interdependencies and dynamic developmental relations associated with learning and problem solving. Systems dynamics model reject the view that causality works in only one direction. These models instead represent intertwining sets of factors interacting in casual loop structures. A dynamic systems model studies the effects of casual feedback structures as they influence input and output flows and impact the resulting accumulations of resources ([1-3].

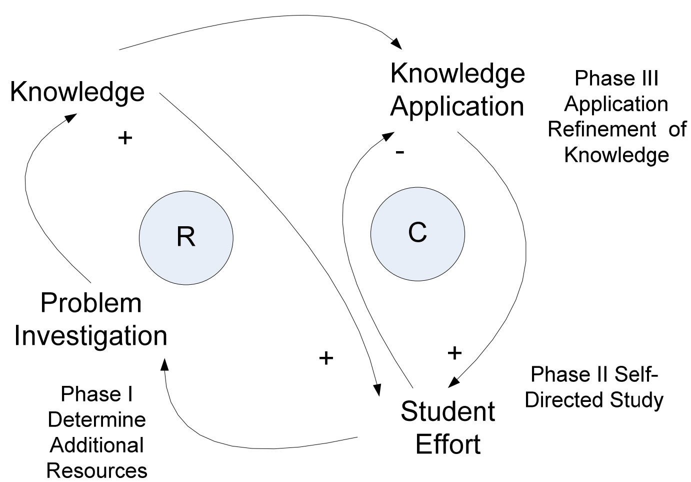
The following defines the phases of PBL and presents a casual-loop diagram to represent casual feedback structures linking phases. The casual model guides the design of a computer simulation model to explore adaptive PBL processes [4]. We present a computer model to simulate the feedback structures and thereby identify a set of working hypotheses that suggest ways to support students as they progress through PBL activities.

CAUSAL LOOP MODEL OF PBL

Figure one presents a set of dynamics feedback loops that represent reciprocal relationships among phases of PBL. Problem Investigation (Phase 1) is affected by the student study effort (Phase 2), which in turn is a function of the current solution approach (Phase 3). Phase 3 is itself affected directly by the accumulation of knowledge directly applicable to the proposed solution. The accumulation of knowledge is, in turn, affected by Phase 1s problem investigations. In this network of causal loops there is no single dependent PBL phase and instead the focus in on the understanding the structural interactions among phases.

The feedback loops in the Figure one can be classified into two main types. Counteracting feedback loops counteract change and return the system to stability. Reinforcing feedback loops drive system changes.

FIGURE 1. CAUSAL LOOP DIAGRAM OF FEEDBACK STRUCTURES FOR PBL PHASES.

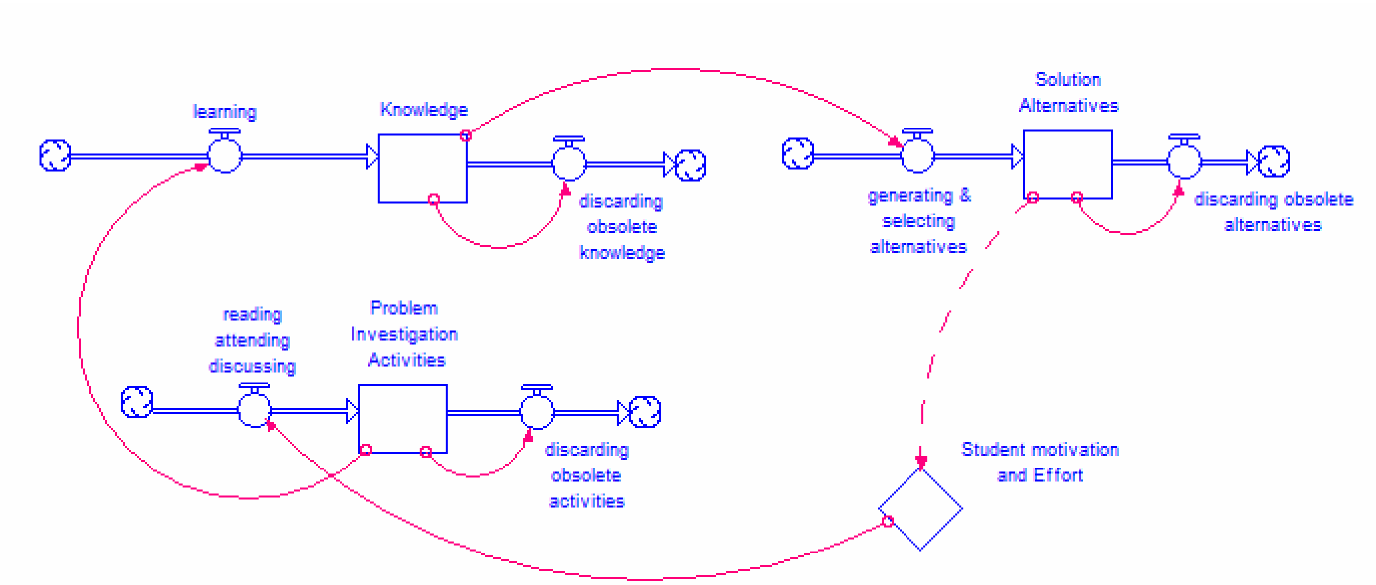


The Simulation Model

Based on the causal loop model, we developed a dynamic computer-based simulation model to explore interactions and feedback loops across PBL activities. The simulation models causal loops as flows that direct input and outputs among accumulated stocks. The resulting computer model allows virtual experiments to test hypotheses associated with pattern of student motivation.

We applied IThink software from ISEE system to create the simulation model [3]. Figure 2 identifies three stocks representing accumulations of 1) Problem investigation activities, 2) knowledge relevant to the problem, 3) solution alternatives.

FIGURE TWO. COMPUTER SIMULATION MODEL OF STOCK AND FLOWS



We identified student motivation and effort as the fuel driving problem solving activities. The simulations tested hypotheses concerning performance driven students, whose efforts will decrease over time, and mastery driven students, whose effort increase over time. The results suggest that performance driven students generate fewer solution alternatives than mastery driven students

In contrast, mastery driven students demonstrate a growth curves that reveals S-shape logistic increases in both effort and generation of solution alternatives. S-shape curves are characteristic of processes that initially grow exponentially and then slow as they reach maturity.

The simulation is sensitive to initial student effort. Low initial effort means lower solution alternatives for both performance and mastery student. The simulations reveal that without sufficient initial effort and even with rapidly increasing effort over time accumulation of solution alternatives continue to decline.

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